Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

Space Environment In-Situ Suite (SEISS)

Performance Operation Requirements Document (PORD)

417-R-PORDSEISS-0030

DRAFT
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National Aeronautics and Space Administration

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1. Scope

1.1. Identification

This Performance and Operations Requirements Document (PORD) sets forth the performance requirements for the National Oceanic and Atmospheric Administration (NOAA) Space Environment In-Situ Suite (SEISS). .

1.2. Mission Objectives

The SEISS objectives are as follows:

- Provide data essential to NOAA's Space Weather Operations and to the long-term record of changing conditions in the space environment.
- Maintain continuity with measurements provided in past and current Geostationary Operational Environmental Satellite (GOES) Series Spacecraft.
- Provide multiple measurements characterizing the charged particle population, including measurements of the electron, proton, and heavy ion fluxes.

1.3. Document Overview

1.3.1. Conflicts

In the event of conflict between the referenced documents and the contents of this SEISS PORD, the contents of this SEISS PORD shall be the superseding requirements.

In the event of a conflict involving the external interface requirements, or in the event of any other unresolved conflict, the NASA contracting officer shall determine the order of precedence.

1.3.2. Requirements Weighting Factors

The requirements stated in this SEISS PORD are not of equal importance or weight. The following defines the weighting factors incorporated in this document.

- "Shall" designates the most important weighting level; that is, mandatory. Any deviations from these contractually imposed mandatory requirements require the approval of the NASA contracting officer.
- "Should" designates an intermediate weighting that indicates the requirements requested by the government are not mandatory. These are GOAL requirements that would greatly enhance the utility of the data if they were met. Unless required by other contract provisions, noncompliance with the "should" requirements does not require approval of the contracting officer, but requires documented technical substantiation.
- "Will" designates a lower weighting level. These will requirements designate the intent of the Government and are often stated as examples of acceptable designs, items, and practices. Unless required by other contract provisions,

noncompliance with the “will” requirements does not require approval of the NASA contracting officer and does not require documented technical substantiation.

1.3.3. Definitions

Throughout this document, the following definitions apply:

Accuracy: Refers to the error in a measurement, that is the difference between the measurement result and the object to be measured (the measured or true value). It includes both systematic and random errors. Systematic errors must be estimated from an analysis of the experimental conditions and techniques. Random errors can be determined, and reduced, through repeated measurements under identical conditions.

All requirements/all performance requirements/ all operational requirements: Refers to any performance characteristic or requirement in the SEISS PORD, SEISS Unique Instrument Interface Document (UIID).

Cadence: The time interval between the start of successive data collection sequences.

Data Latency: The time interval between the end of a data collection sequence and the time that the data is available at the spacecraft interface.

Eclipse: Defined as when the solar disk is completely occulted by the Earth or Moon, as viewed from the GOES satellite.

Flux: The number of particles crossing a unit area from a unit solid angle in a unit time. The directional-differential flux is given in units: $(cm^2\ s\ sr\ keV)^{-1}$ or $(cm^2\ s\ sr\ MeV)^{-1}$ and the directional-integral flux is given in units: $(cm^2\ s\ sr)^{-1}$.

Launch: The period of time between lift off and the separation of the GOES-R series satellite from the launch vehicle. The duration of launch is expected to be less than 2 hours long.

Precision: Refers to the standard deviation of a statistically meaningful number of samples of a measurement.

Resolution: Refers to the standard deviation of a statistically meaningful number of samples of a measurement.

Station keeping: Inclination and East/West control.

TBD: Meaning "to be determined" is applied to a missing requirement. The missing requirement will be determined through the course of the contract execution.

TBR: Meaning "to be reviewed" implies that the requirement is subject to review for appropriateness by the contractor or the government. The government may change “TBR” requirements in the course of the contract.

TBS: Meaning "to be specified", indicates that the government will supply the missing information in the course of the contract.

Threshold: The minimum performance characteristic that is acceptable.

Transfer Orbit: The sequence of events that transpires to establish the GOES-R series satellite on-station after the GOES-R series satellite has separated from the launch vehicle.

Yaw Flip: The spacecraft interchanges North and South faces of the spacecraft as defined in section TBD of the GIRD.

1.3.4. Requirement Applicability

All requirements shall apply over the entire life of the SEISS.
All requirements in this SEISS PORD apply to data after all ground processing except as indicated.

1.3.5. Requirements Overview

This document contains all performance requirements for the instruments except those labeled “TBD,” “TBS,” and “TBR.” The term “TBD,” meaning “to be determined,” applied to a missing requirement means that the contractor should determine the missing requirement in coordination with the government. The term “TBS,” meaning “to be specified,” indicates that the government will supply the missing information in the course of the contract. The term “TBR,” meaning to be reviewed,” implies that the requirement is subject to review for appropriateness by the contractor or the government. The government may change “TBR” requirements in the course of the contract.

2. Applicable Documents

The following documents are referenced within this specification.

GOES R Series Mission Assurance Requirements Document (MAR), NASA GSFC, Document Number 415-R-MAR-0012, dated XXX.

General Interface Requirements Document (GIRD), NASA GSFC, Document Number 417-R-GIRD-0009, dated June, 2003.

SEISS Unique Instrument Interface Requirements Document (UIID), NASA GSFC, Document Number 417-R-UIIDSEISS-xxxx, TBD.

NOAA's Mission Requirements Document 1A (MRD-1A) for the GOES-R Series, Version 2.0, July 16, 2003.

3. Sensor Requirements

3.1. Sensor Definition

3.1.1. SEISS Overview and Description

The SEISS particle sensors shall monitor the proton, electron, and heavy ion fluxes at geosynchronous orbit. These particle fluxes roughly consist of three components: 1) a geomagnetically trapped and highly variable population of electrons and protons; 2) sporadic fluxes of electrons, protons, and heavy ions of direct solar origin (e.g. from flares); and 3) a background of galactic cosmic rays ranging from several MeV to highly relativistic energies. Knowledge of the near-Earth energetic particle environment is important in establishing the natural radiation hazard to humans at high altitudes and in space, as well as risk assessment and warning of episodes of surface charging, deep dielectric charging, and single event upset of satellite systems. Energetic particle precipitation into Earth's ionosphere also causes disturbance and disruption of radio communications and navigation systems.

The SEISS particle sensors shall include a magnetospheric particle sensor (MPS), a solar and galactic proton sensor (SGPS), and an energetic heavy ion sensor (EHIS).

3.1.2. SEISS Operational Modes

All SEISS modes and their functions shall be documented in the Interface Control Document (ICD).
The SEISS shall execute ground commands to individually enable and disable each autonomous function of the SEISS.
Transitions to Safe Mode, whether commanded or autonomous, shall require no more than TBD second(s) to initiate.
All SEISS instruments shall operate independently.
The SEISS instruments shall provide telemetry that identifies the current mode of operation of the instrument. This telemetry shall be provided at the same rate as the instrument data.

3.1.3. On Orbit Operations

3.1.3.1. Normal Operations Mode

The SEISS instruments will conduct regular operations, while flying aboard a 3 axis stabilized, geostationary spacecraft with orbital limit constraints as stated in the SEISS GIRD and/or the SEISS UIID.

All SEISS instruments shall implement a Normal Operational Mode.
In Normal Operational Mode, the SEISS instruments shall be in a fully functional configuration.

3.1.3.2. Instrument Diagnostic State

The SEISS instruments shall implement an Instrument Diagnostic State.
In the Instrument Diagnostic State, the SEISS instruments shall, as a minimum, perform the following:

- Download RAM contents.
- TBD

3.1.3.3. Initial Activation

The instruments shall be fully functional within TBD days from launch.
The SGPS and EHIS shall be turned on within TBD minutes following launch.

3.1.3.4. Eclipse

The SEISS instruments shall operate and transmit data without reduction in performance during eclipses.

3.1.3.5. Yaw Flip

The SEISS instruments shall be in Normal Operations Mode while the spacecraft executes a yaw flip and after the spacecraft has executed a yaw flip.

3.1.3.6. Station keeping

The SEISS instruments shall operate and transmit data during spacecraft stationkeeping maneuvers.

3.1.3.7. Activation

The SEISS instruments shall meet all requirements within 30 minutes of SEISS turn on.

3.1.3.8. Operation During Transfer Orbit

The SEISS instruments shall operate during transfer orbit. The instruments shall be turned on after TBD hours after launch.

3.1.3.9. On Orbit Storage

The SEISS shall operate during on orbit storage.

3.1.3.10. Safe Mode

The SEISS instruments shall have a safe mode.
The instruments shall enter safe mode either upon command or autonomously upon detection of potentially harmful anomalies.
The limits and triggers for anomaly responses shall be accessible and changeable by ground command.

3.2. Sensor Requirements

3.2.1. General Requirements

The requirements in this section apply to all instruments of the SEISS.

3.2.1.1. Noise

For bands below 30 keV, the total instrument noise (including that from the detector, background, and electronics) shall not exceed 10% of the energy resolution. For bands with threshold energies between 30 keV and 100 keV, noise shall not widen the effective response by more than 10 keV. For bands above 100keV, noise shall not widen the effective response by more than 10% of a band's threshold energy.

3.2.1.2. Stability

The electronic discriminator levels defining the energy band edges shall not change by more than 3% over the predicted operating conditions.

3.2.1.3. In-Flight Calibration

The instruments shall have an in-flight calibration mode. This mode shall verify basic instrument operation and determine the value of the energy band edges. Electronic discriminator levels shall be determined to 3%.
The in-flight calibration shall be both self-terminating and able to be terminated by ground command.

3.2.1.4. Ground Calibration

The instruments shall be fully characterized prior to delivery, including the measurement of the instrument response to in-band (including direction, energy, and species) and out-of-band particles.

The energy dependent and the directional responses of the instruments shall be determined for energies ranging from the detector's low-energy threshold to energies for which the particle flux is below the instrument detection threshold.

3.2.1.5. Out-of-Band Response

The response of the data channels to out-of-band particles (including direction, energy, and species) shall not exceed 10% of the response to in-band particles. Correction algorithms for the out-of-band response may be provided if necessary to comply with this requirement.

3.2.1.6. Lifetime

The SEISS instruments **shall** have a 10-year instrument on time after a maximum of 5 years on orbit storage and after a maximum of 5 years of ground storage. The mean mission duration (MMD), namely the integrated area under the reliability versus time curve for the instrument shall be 8.4 years with a reliability of 0.6.

3.2.1.7. On-Board Processors (OBP)

3.2.1.7.1. Commandability of Redundant On-Board Processor Configuration

The operational configuration of OBP redundant components shall be commandable and configurable from the ground.

3.2.1.7.2. Flight Load Non-volatile Memory

The entire flight software image shall be contained in non-volatile memory at launch.

3.2.1.7.3. Ground Commandable OBP Reboot/Reinitialization

The OBP shall provide for reset by ground command of software for recovery from instrument anomalies, including software anomalies.

3.2.1.7.4. Deterministic Power-on Configuration

The OBP shall initialize upon power-up into a predetermined configuration.

3.2.1.7.5. Failsafe Recovery Mode

The Instrument shall provide a failsafe recovery mode dependant on a minimal hardware configuration that is capable of accepting and processing a minimal command subset sufficient to load and dump memory.

In failsafe recovery mode the instrument shall be commandable to begin execution at a specified memory address.

3.2.1.8. Flight Software

3.2.1.8.1. Language and Methodology

All software developed for the SEISS instrument shall be developed with ANSI/ISO standard languages and a widely-accepted, industry-standard, formal software design methodology. Minimal use of processor-specific assembly language is permitted for certain low-level programs such as interrupt service routines and device drivers with NASA approval.

3.2.1.8.2. Software Module Upload

The flight software shall be reprogrammable on-orbit to allow for new versions of software segments and table values to be loaded from the ground without computer restart.

Rationale: Software should be patchable without having to replace the entire image.

3.2.1.8.3. Flexibility and Ease of Software Modification

The SEISS flight software design shall be flexible and table-driven for ease of operation and modification.

The SEISS flight software shall be rigid in terms of scheduling and prioritization of critical processing tasks to ensure their timely completion.

All software data that are modifiable and examinable by ground operators shall be organized into tables that can be referenced by table number so table data can be loaded and dumped by the ground without reference to memory address.
Rationale: G*round software and databases should not need to change when data are relocated by a recompilation of the flight software.*

The definition of instrument commands within the ground database shall not be dependent on physical memory addresses within the flight software.
Rationale: All commands processed by the flight software (with the exception of loads and dumps by address) should be interpreted by the flight software without the use of any uploaded physical address. Existing command definitions in the database should be unaffected when the flight software is recompiled.

3.2.1.8.4. Version Identifiers in Embedded Code

All software and firmware versions shall be implemented with an internal identifier (embedded in the executive program) that can be included in the instrument engineering data.

This software identifier shall be keyed to the configuration management process so that the exact version of software and firmware residing in the instrument can be determined at any time.

3.2.1.8.5. Flight Processor Resource Sizing

During development, flight processors providing computing resources for instrument subsystems shall be sized for worst case utilization not to exceed the capacity shown below (measured as a percentage of total available resource capacity):

Flight Processor Resource Utilization Limits

	S/W PDR	S/W CDR	S/W AR
RAM Memory	40%	50%	60%
ROM Memory	50%	60%	70%
CPU	40%	50%	60%

3.2.1.8.6. Software Event Logging

The flight software shall include time-tagged event logging in telemetry.

The event messages shall capture all anomalous events, redundancy management switching of instrument components, and important system performance events.

All flight software components shall utilize a common format for event messages.

The flight software shall provide a means for ground command to enable and disable queueing of individual event messages.

The flight software shall buffer a minimum of 1000 event messages while the event messages are queued for telemetering to the ground.

The event message queue shall be configurable by ground command to either (a) discard the new events, or (b) overwrite oldest events when the queue is full.

The flight software shall maintain counters for:

a) the total number of event messages generated
b) the number of event messages discarded because of queue overflow
c) the number of event messages not queued due to being disabled.

3.2.1.8.7. Warm Restart

The flight software shall provide a restart by ground command with preservation of the event message queue and memory tables.

3.2.1.8.8. Memory Tests

The flight software shall provide a mechanism to verify the contents of all memory areas.

3.2.1.8.9. Memory Location Dump Capability

The flight software, and associated on-board computer hardware, shall provide the capability to dump any location of on-board memory to the ground upon command.

The flight software memory dump capability shall not disturb normal operations and instrument data processing.

3.2.1.8.10. Telemetry

Telemetry points sampled by the instrument shall be controlled by an on-orbit modifiable table.

The sample rate of every instrument telemetry point shall be controlled by an on-orbit modifiable table.

3.2.1.9. Mechanical

Each instrument unit structure shall possess sufficient strength, rigidity and other characteristics required to survive the critical loading conditions that exist within the envelope of handling and mission requirements.

3.2.1.9.1. Design and Test Factors of Safety

The instrument contractor shall use the prototype factors of safety specified in NASA-STD-5001 for analysis and verification of structural units not containing beryllium.

The instrument contractor shall use a proof test factor, yield and ultimate factors of safety of 1.4, 1.45 and 1.6 respectively for structural elements containing beryllium.

3.2.1.9.2. Design Limit Loads

The structure shall be capable of withstanding all limit loads without loss of any required function.
Rationale: Limit loads are defined as all worst case load conditions including temperature effects from the environments expected during all phases of the structure's service life including manufacturing, ground handling, transportation, environmental testing, integration, pre-launch, launch and on-orbit operations and storage.

3.2.1.9.3. Non-Linear Loads

The flight unit structures shall be capable of withstanding redistribution of internal and external loads resulting from any non-linear effects including deflections under load.

3.2.1.9.4. Yield Strength

The flight unit structures shall be able to support yield loads without detrimental permanent deformation.
Rationale: Strength requirements are specified in terms of yield and ultimate loads. Yield loads are limit loads multiplied by prescribed factors of safety.

While subjected to any operational load up to yield operational loads, the resulting deformation shall not interfere with the operation of the instrument flight unit. .

3.2.1.9.5. Ultimate Strength

The unit structures shall be able to support ultimate loads without failure for at least 3 seconds including ultimate deflections and ultimate deformations of the flight unit structures and their boundaries. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the 3-second limit does not apply.
Rationale: *Strength requirements are specified in terms of yield and ultimate loads. Ultimate loads are limit loads multiplied by prescribed factors of safety.*

3.2.1.9.6. Structural Stiffness

Stiffness of the flight unit structures and their attachments shall be designed by consideration of their performance requirements and their handling, transportation and launch environments.

Special stowage provisions shall be used if required to prevent excessive dynamic amplification during handling, transportation and transient flight events.

3.2.1.9.7. Unit Stiffness

The fundamental resonant frequency of an instrument flight unit shall be 50 Hz (TBR) or greater when the flight unit is constrained at its spacecraft interface.

3.2.1.9.8. Material Properties

Material properties shall be based on sufficient tests of the material meeting approved specifications to establish design values on a statistical basis.

Design values shall account for the probability of structural failures and loss of any required function due to material variability.

The instrument contractor shall specify the source and statistical basis of all material properties used in the design.

The effects of temperature on design values shall be considered.

3.2.1.9.9. Critical Members Design Values

For critical members, design values shall be selected to assure strength with a minimum of 99 percent probability and 95 percent confidence.

Structural members are classified as critical when their failure would result in loss of structural integrity of the flight units.

3.2.1.9.10. Redundant Members Design Values

For redundant members, design values shall be selected to assure strength with a minimum of 90 percent probability and 95 percent confidence.

Structural members are classified as redundant when their failure would result in the redistribution of applied loads to other structural members without loss of structural integrity.

3.2.1.9.11. Selective Design Values

As an exception to Sections "Critical Members Design Values" and "Redundant Members Design Values", greater design values may be used if a representative portion of the material used in the structural member is tested before use to determine that the actual strength properties of that particular structural member will equal or exceed those used in the design.

3.2.1.9.12. Structural Reliability

The strength, detailed design, and fabrication of the structure shall prevent any critical failure due to fatigue, corrosion, manufacturing defects and fracture throughout the life of the instrument resulting in the loss of any mission objective.

Accounting for the presence of stress concentrations and the growth of undetectable flaws, the instrument flight unit structures shall withstand loads equivalent to four complete service lifetimes.

While subjected to any flight operational load up to limit flight operational loads, the resulting deformation of the residual instrument flight unit structures shall not interfere with the operation of the instrument flight unit..

After any load up to limit loads, the resulting permanent deformation of the residual instrument flight unit structures shall not interfere with the operation of the instrument flight unit.

3.2.1.9.13. Mechanisms

Deployment, sensor, pointing, drive, separation mechanisms and other moving mechanical assemblies may be designed using MIL-A-83577B and NASA TP-1999-206988.

All instrument mechanisms shall meet performance requirements while operating in an earth gravity environment with any orientation of the gravity vector(TBR).

Moving mechanical assemblies shall have torque and force ratios per section 2.4.5.3 of GEV-SE using a NASA approved classification of each instrument mechanism.

For all operating points of the actuators, all rotational actuators shall have available a continuous maximum torque output greater than 7.0 milli-Newton meters.

For all operating points of the actuators, all linear actuators shall have available a continuous maximum force output greater than 0.28 N.

For mechanisms using closed-loop control, gain and phase margins shall be greater than 12 dB, and greater than 40 degrees, respectively. The margins shall include the effects of the dynamic properties of any flexible structure.

All instrument mechanisms requiring restraint during launch shall be caged during launch without requiring power to maintain the caged condition.

All instrument mechanisms requiring restraint shall be released from a caged condition by command.

All instrument mechanisms requiring restraint shall be returned to a caged condition ready for launch by either command or by manual actuation of an accessible caging device.

3.2.1.9.14. Magnetic

The instrument shall not have uncompensated magnetic moment greater than 0.0005 ampre-turn meter-square per kilogram of mass (TBR).

3.2.1.9.15. Pressurized Units

Instruments with pressurized systems shall follow the requirements in accordance with EWR-127-1 and MIL-STD-1522A for the design of pressurized systems.

The instrument shall have no open fluid reservoirs when delivered to the spacecraft contractor.

3.2.1.10. Thermal – Design and Construction Standards

3.2.1.10.1. Temperature Limits

The instrument contractor shall establish Mission Allowable Temperatures (MAT) for the instrument with at least 5^{O} C of analytical/test uncertainty.
Rationale: Thermal margin is defined as the temperature delta between MAT versus the bounding predictions plus analytical uncertainty.

Figure 3.4.2.1.1 Temperature Requirement Graphic

TBS

The instrument shall maintain thermally independent units and their internal components within Mission Allowable Temperatures (MAT) limits during all flight operational conditions including bounding worst-case environments.

3.2.1.10.2. Outgassing Temperature Requirements

The instrument shall maintain the thermally independent units and their internal components within Out-gassing Allowable Temperatures (OAT) during all out-gassing procedures.

3.2.1.10.3. Non Operational Temperature Requirements - NOT

The Non-Operational Temperatures (NOT) range shall extend at least 20^{O} C warmer than the hot MAT and at least 20^{O} C colder than the cold MAT.

The cold Non-Operational Temperature shall be -25^{O} C or colder.

3.2.1.10.4. Thermal Control Hardware

There shall be two or more serial and independent controls for disabling any heater where any failed on condition would cause over-temperature conditions or exceed the instrument power budget.
Rationale: Independent controls include thermostats, relays and other switches.

The instrument heaters shall be sized to have 25% margin for worst case conditions.

When the instrument is off, instrument survival heaters shall maintain independent unit temperatures above non-operational limits.
Rationale: The only intended use of survival heaters willl be to maintain non-operational temperatures when the instrument is off.

Instrument survival heaters shall be thermostatically controlled.

3.2.1.11. Multi-Layer Insulation

Multilayer insulation (MLI) shall have provisions for venting and electrical grounding to prevent Electro-Static Discharge (ESD).

3.2.2. MPS Requirements

3.2.2.1. Low Energy Electrons and Protons

3.2.2.1.1. Flux Measurement Range

The MPS shall provide low energy electron and proton flux measurements in the range 30 eV to 30 keV.
As a threshold, the MPS shall determine the proton and electron flux in 15 evenly spaced logarithmic energy bands per species.
As a goal, the MPS should determine the proton and electron flux in 20 evenly spaced logarithmic energy bands per species.

3.2.2.1.2. Accuracy

The MPS shall have a flux measurement accuracy of 10%, determined through ground calibration.

3.2.2.1.3. Spatial Coverage and Field of View

The MPS shall have at least five non-overlapping elevation bins (above and below the equatorial plane) spanning a total acceptance angle of 170° centered on either the Earthward or the anti-Earthward direction and symmetrical above and below the equatorial plane. In addition, as a goal, the MPS should have five non-overlapping azimuthal bins (in the equatorial plane) spanning an acceptance angle of 170° centered on either the Earthward or the anti-Earthward direction and symmetrical East and West. This resolution may be accomplished with a total of nine angle bins; five in azimuth and five in elevation with the center bin common to both planes of coverage.

3.2.2.1.4. Data Rate

As a threshold, the refresh rate shall be 30 seconds.
As a goal, the refresh rate should be 10 seconds.
The time from the data collection until it is available at the spacecraft interface shall be less than 5 seconds. TBR

3.2.2.1.5. Maximum and Minimum Flux

a) Electrons

The MPS shall be able to measure the electron flux according to the following energy spectra (E is the energy in keV):

Minimum flux: Flux $[\mathrm{cm}^{-2}\ \mathrm{s}^{-1}\ \mathrm{sr}^{-1}\ \mathrm{keV}^{-1}] = 9. \times 10^{4}\ E^{-1.3}$

Maximum flux: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = 1.5 x 10^9 $E^{-1.3}$

b) Protons

Minimum flux: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = 40. $E^{-0.8}$

Maximum flux: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = 1.1 x 10^7 $E^{-0.8}$

This minimum flux must be detected with a minimum of 10 counts above background (a signal-to-noise ratio of 3) in each energy channel over a 5 minute interval.

3.2.2.2. Medium and high energy electrons and protons

3.2.2.2.1. Measurement Range

The MPS shall measure electron flux in the range of 30 keV to 4 MeV.
As a threshold, the MPS shall determine the electron flux in 10 evenly spaced logarithmic energy bands plus one integral channel for energies greater than 2 MeV. As a goal, the MPS should determine the electron flux in 15 evenly spaced logarithmic energy bands plus one integral channel for energies greater than 2 MeV.

The MPS shall measure proton flux in the range of 30 keV – 1 MeV.
As a threshold, the MPS shall determine the proton flux in 7 evenly spaced logarithmic energy bands.
As a goal, the MPS should determine the proton flux in 10 evenly spaced logarithmical energy bands.

3.2.2.2.2. Accuracy

The MPS shall have a flux measurement accuracy of 10%, determined through ground calibration.

3.2.2.2.3. Spatial Coverage and Field of View

The MPS shall have at least five non-overlapping elevation bins (above and below the equatorial plane) spanning a total acceptance angle of at least 170° centered on the anti-Earthward direction and symmetrical above and below the equatorial plane. In addition, the MPS should have five non-overlapping azimuthal bins (in the equatorial plane) spanning an acceptance angle of at least 170° centered on the Earthward or anti-Earthward direction and symmetrical East and West. This resolution may be accomplished with a total of nine angle bins; five in azimuth and five in elevation with the center bin common to both planes of coverage.

3.2.2.2.4. Data Rate

The refresh rate shall be 30 seconds.
The refresh rate should be 10 seconds.
The time from the end of the data collection and the time that the data is available at the spacecraft interface shall be 5 seconds. TBD

3.2.2.2.5. Maximum and Minimum Flux

a) Electrons

The MPS shall be able to measure the electron flux according to the following energy spectra (*E* is the energy in keV):

Minimum flux:
0.030– 4 MeV: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = $1.2 \times 10^{7} E^{-2.8}$

Maximum flux:
0.030– 4 MeV: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = $2.3 \times 10^{11} E^{-2.8}$

b) Protons

The MPS shall be able to measure the proton flux according to the following energy spectra (*E* is the energy in keV):

Minimum flux:
0.030– 1 MeV: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = $8. \times 10^{2} E^{-1.8}$

Maximum flux:
0.030– 1 MeV: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = $5 \times 10^{7} E^{-1.3}$

This minimum flux must be detected with a minimum of 10 counts rounded to the nearest integer above background (a signal-to-noise ratio of 3) in each energy channel over a 5 minute interval.

3.2.3. SGPS Requirements

3.2.3.1. Measurement Range

The SGPS shall provide proton flux measurements in the energy range from 1 MeV to >500 MeV.
As a threshold, the flux shall be determined in 10 evenly spaced logarithmic energy bands up to 500 MeV plus one integral band for energies greater than 500 MeV. As a goal, the flux should be determined in 20 evenly spaced logarithmic energy bands up to 500 MeV plus one integral band for energies greater than 500 MeV.

3.2.3.2. Accuracy

The SGPS shall have a flux measurement accuracy of 10%, determined through ground calibration.

3.2.3.3. Spatial Coverage and Field of View

The SGPS shall have a minimum of two look-directions with identical viewing geometries, both centered in elevation on the equatorial plane, with one centered in the eastward direction and one centered in the westward direction.

3.2.3.4. Data Rate

The refresh rate shall be 1 minute.
The refresh rate should be 30 seconds.
The time from the end of the measurement interval until the data is available at the spacecraft interface shall be 5 seconds TBR.

3.2.3.5. Minimum and Maximum Flux

The SGPS shall resolve the largest likely solar particle event. The spectrum for this event can be represented as (E is the energy in keV):

Minimum flux: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = $8. \times 10^{2} E^{-1.8}$

Maximum flux: Flux [cm^{-2} s^{-1} sr^{-1} keV^{-1}] = $2. \times 10^{12} E^{-2.8}$

This minimum flux must be detected with a minimum of 10 counts rounded to the nearest integer above background (a signal-to-noise ratio of 3) in each energy channel over a 5 minute interval.

3.2.4. EHIS Requirements

3.2.4.1. Measurement Range

The EHIS shall provide flux measurements in the energy range from 10 MeV/nucleon to 400 MeV/nucleon.
The EHIS shall detect and distinguish between the following mass groups: He, C-N-O, Ne-S, and Fe. As a threshold, the flux shall be determined in 7 evenly spaced logarithmic energy bands within the specified range.
As a goal, the flux should be determined in 10 evenly spaced logarithmic energy bands within the specified range.

3.2.4.2. Accuracy

The EHIS shall have a flux measurement accuracy of 10%, determined through ground calibration.

3.2.4.3. Spatial Coverage and Field of View

The EHIS shall have one look direction, centered in the Earthward or anti-earthward direction.

3.2.4.4. Data Rate

The refresh rate shall be 5 minutes.
The time from the end of data collection until the data is available at the spacecraft interface shall be less than 5 seconds.TBR

3.2.4.5. Minimum and Maximum Flux

The EHIS shall measure the heavy ion abundances during the largest likely solar particle event. The ion abundances for such an event are given below. All abundances have been normalized to O = 1000. The minimum and maximum fluxes for O can be represented as (E is the energy in MeV):

Maximum flux for O:

$10 \leq E < 80$ MeV/nuc	Flux [cm^{-2} s^{-1} sr^{-1} MeV/nuc^{-1}] = $4.5\ E^{-3.6}$
$E \geq 80$ MeV/nuc	Flux [cm^{-2} s^{-1} sr^{-1} MeV/nuc^{-1}]= $1.1 \times 10^{-7}\ E^{0.4}$

Minimum flux for O:

$10 \leq E < 80$ MeV/nuc	Flux [cm^{-2} s^{-1} sr^{-1} MeV/nuc^{-1}] = $1.5 \times 10^{-4}\ E^{-1.7}$
$E \geq 80$ MeV/nuc	Flux [cm^{-2} s^{-1} sr^{-1} MeV/nuc^{-1}] = $4.1 \times 10^{-9}\ E^{0.7}$

This minimum flux must be resolved with a minimum of 10 counts rounded to the nearest integer above background (signal to noise ration of 3) in each energy channel over a 5 minute interval.

Element	Z	Abundances (SEP events)	Abundances (quiet times during solar min)
He	2	57000	1612
C	6	465	7
N	7	124	139
O	8	1000	1000
Ne	10	152	74
Na	11	10.4	0.2
Mg	12	196	1.0
Al	13	15.7	0.1
Si	14	152	1.4
P	15	0.65	0.1
S	16	31.8	0.47
Fe	26	134	0.8

4. Acronyms

PORD	Performance and Operations Requirements Document
NOAA	National Oceanic and Atmospheric Administration
SEISS	Space Environment In-Situ Suite
GOES	Geostationary Operational Environmental Satellite
UIID	Unique Instrument Interface Document
GIRD	General Interface Requirements Document
MAR	Mission Assurance Requirements
TBD	To Be Determined
TBS	To Be Supplied
TBR	To Be Reviewed
EHIS	Energetic Heavy Ion Sensor
SGPS	Solar and Galactic Proton Sensor
MPS	Magnetospheric Particle Sensor